ART. V. THE CEPHALOPOD FAUNA OF THE CONEMAUGH SERIES IN WESTERN PENNSYLVANIA

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(Plates I-VIII)

Introduction and Acknowledgments

Very little information has heretofore been published in regard to the cephalopods of the Conemaugh series in Pennsylvania. Aside from incidental references by Rogers, Meek, Plummer and Scott, and others, the only significant data are those given by Raymond in 1910 and 1911 in his *Preliminary list of the fauna of the Allegheny and Conemaugh series in western Pennsylvania.* Essentially all of Raymond's cephalopods have been available to us for restudy, and they are therefore included in the following discussions.

The bulk of the specimens on which our study is based were collected by Mr. David Seaman, and any merit our report may possess is primarily a result of his diligence. Additional material was loaned by Dr. I. P. Tolmachoff, who collected some of the specimens himself, and by Dr. John W. Wells, who likewise assembled collections in the field. Some of the better specimens found by Dr. Wells were obtained by us indirectly in the John Britts Owen Collection, which is now at the State University of Iowa.

The photographs which accompany this report were retouched by Mr. Howard Webster, who also inked the line drawings. Finally, we wish to acknowledge our indebtedness to the Graduate College of the State University of Iowa and particularly to Mr. Frederick O. Thompson of Des Moines, who made the work financially possible.

Stratigraphic Faunal Summary

Marine fossils occur in the Conemaugh of western Pennsylvania in at least five formations, the Brush Creek, Pine Creek, Woods Run, Ames, and Birmingham. The fauna known from the Woods Run and the Birmingham is not large, but the other three have yielded a variety of fossils at a good many localities. Their faunas are primarily molluscan but they also contain a few fusulinids, corals, crinoids, bryozoans, trilobites, fish teeth, and numerous brachiopods. Cephalopods are known from all five of these fossiliferous horizons.

In western Pennsylvania the Brush Creek limestone, about one hun-

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dred feet above the base of the Conemaugh, carries a large and varied fauna in which molluscs predominate, and it has yielded far more cephalopods than any other Conemaugh formation. Altogether, representatives of nine genera of nautiloids and three of ammonoids are known from this formation as follows:

Pseudorthoceras knoxense (McChesney)
Mooreoceras normale Miller, Dunbar, and Condra
Poterioceras curtum (Meek and Worthen)
Ephippioceras ferratum (Cox)
Megaglossoceras sp.
Liroceras sp.
Metacoceras cornutum Girty
Metacoceras perelegans Girty
Domatoceras sp.
Solenochilus brammeri Miller, Dunbar, and Condra (?)
Pennoceras seamani, gen. et sp. nov.
Eoasianites sp.
Schistoceras hildrethi (Morton)
Schistoceras missouriense (Miller and Faber)

It should be emphasized that this list contains all of the cephalopod species known to occur in the entire Conemaugh of Pennsylvania except *Tainoceras monilifer* Miller, Dunbar, and Condra. That species has not been found below the Woods Run limestone. The fauna of the Brush Creek is especially large because that formation is widespread in western Pennsylvania, outcrops of it are relatively abundant, and lithologically it consists of limestone and shale in about the right proportions to preserve fossils well and to yield them readily.

The Pine Creek limestone, which occurs from sixty to ninety feet above the Brush Creek, also contains a considerable fauna, but good specimens can be obtained at only a few places. Raymond (1911, p. 88) states that at "almost every locality where fossils have been collected from this layer nautiloids have been found to be numerous, but not well preserved." The collections we are studying contain representatives of four nautiloid genera from this formation:

Pseudorthoceras knoxense (McChesney)
Metacoceras cornutum Girty
Metacoceras perelegans Girty
Domatoceras sp.
Solenochilus brammeri Miller, Dunbar, and Condra(?)

Raymond's lists indicate that *Pennoceras seamani* is also present in the Pine Creek, but none of his specimens that we have studied can be referred to that species or genus. It is worthy of note that all of the species represented in the Pine Creek occur also in the Brush Creek.

The Woods Run limestone is of very local distribution and only a few outcrops of it are known. It has yielded a meager fauna, but we now have representatives of four nautiloid and one ammonoid genera from it:

Ephippioceras ferratum (Cox)
Metacoceras cornutum Girty
Tainoceras monilifer Miller, Dunbar, and Condra
Domatoceras sp.
Schistoceras hildrethi (Morton)

Tainoceras monilifer apparently makes its appearance in the Conemaugh at this horizon. All of the other cephalopod species obtained from the Woods Run are also known from lower beds and, with a single exception, from younger ones.

The Ames limestone, which in western Pennsylvania occurs stratigraphically about 125 feet above the Pine Creek, is abundantly fossiliferous. However, as is so often the case, good specimens can be obtained at only a relatively few localities. This formation contains many brachiopods and crinoid columnals and also a considerable fauna of gastropods and fish teeth, as well as the following species of cephalopods:

Pseudorthoceras knoxense (McChesney)
Mooreoceras normale Miller, Dunbar, and Condra
Poterioceras curtum (Meek and Worthen)
Metacoceras cornutum Girty
Metacoceras perelegans Girty?
Tainoceras monilifer Miller, Dunbar, and Condra
Domatoceras sp.
Schistoceras hildrethi (Morton)

The Ames is the youngest abundantly fossiliferous marine formation in the Conemaugh of Pennsylvania. For the most part its fauna is strikingly similar to that of the Brush Creek.

According to Raymond the Birmingham shale generally varies from thirty-five to fifty feet in thickness, and its base is about thirty feet above the Ames limestone. A few marine fossils have been found in it. These consist of brachiopods, clams, gastropods, and three cephalopods. Two of the three cephalopods are poorly preserved fragments, but they are probably referable to *Tainoceras monilifer* Miller, Dunbar, and Condra,

which is fairly abundant in the Ames and occurs also in the Woods Run.

Insofar as cephalopods are concerned, the fauna of the Conemaugh is a unit, and it probably represents only one invasion. That is, the youngest abundant fauna known from the series, that of the Ames, is essentially the same as the oldest abundant fauna, that of the Brush Creek. Future collecting will almost certainly serve to emphasize the similarities and eliminate the apparent differences in the faunas of these two limestones.

Most of the nautiloid species found in the Conemaugh are not very valuable for precise correlations. Furthermore, of the four types of ammonoids known from the series, one represents a new genus and species, and the other three are long-ranging forms. Nevertheless, the cephalopod assemblage can be said to substantiate the generally accepted view that the Conemaugh is of about the same age as the McLeansboro of Illinois and the Kansas City and Lansing of Missouri, Kansas, and Nebraska.

TABLE 1. Stratigraphic distribution of cephalopods in the Conemaugh of western Pennsylvania.

Species \ Horizon	Brush Creek	Pine Creek	Woods Run	Ames	Birmingham
Pseudorthoceras knoxense	×	×	.	×	×
Mooreoceras normale	×	.	.	×	.
Poterioceras curtum	×	.	.	×	.
Ephippioceras ferratum	×	.	×	.	.
Megaglossoceras sp.	×	?	.	.	.
Liroceras sp.	×	.	.	.	.
Metacoceras cornutum	×	×	×	×	.
Metacoceras perelegans	×	×	.	×	.
Tainoceras monilifer	.	.	×	×	×
Domatoceras spp.	×	×	×	×	.
Solenochilus brammeri?	×	×	.	.	.
Pennoceras seamani	×	?	.	.	.
Eoasianites sp.	×	.	.	.	.
Schistoceras hildrethi	×	.	×	×	.
Schistoceras missouriense	×	.	.	.	.

SYSTEMATIC PALEONTOLOGY

Genus PSEUDORTHOCERAS Girty, 1911

Pseudorthoceras knoxense (McChesney)

(Plate I, figures 1-5)

This species was recently described in detail by Miller, Dunbar, and Condra (1933, pp. 77-85), who also listed its extensive synonymy; there is of course no need for us to duplicate this work. The most distinctive character of the species is perhaps the curved adapical portion of its conch, which is therefore a cyrtoceracone. Specimens of which the adapical portion of the conch is not preserved can be recognized by the peculiar deposits in the camerae. Miller, Dunbar, and Condra, who described these deposits in detail, concluded that they were formed in the adapical portion of the living chamber, but it now seems more probable that they were secreted in the camerae, a view that has recently been presented by both Teichert and Flower.

In the collections that we are studying, *P. knoxense* is associated with *Mooreoceras normale*. Even fragmentary specimens of these two forms are easily differentiated without sectioning by the fact that in *P. knoxense* the siphuncle is central in position whereas in *M. normale* it is distinctly ventrad of the center, though not marginal. Also, the conch of *P. knoxense* is more rapidly expanded than is that of *M. normale*. Most of the representatives of *P. knoxense* known from the Conemaugh of Pennsylvania are crushed and fragmentary and are not very well preserved. All of them appear to represent portions of the phragmacone.

Occurrence: This species is widely distributed in the Pennsylvanian of North America and may occur also in Europe (Carnic Alps). Stratigraphically it ranges from the Cherokee to the Wabaunsee and from the Bend to the Cisco; geographically it ranges from Pennsylvania on the east to Colorado on the west, and from Texas on the south to Michigan on the north. Representatives are known from the following horizons and localities in the Conemaugh of Pennsylvania: the Brush Creek limestone near Ambridge (about two miles east of), Creighton, Donohoe, Glassmere (Harvy Brick Company quarry), Witmer, Ligonier (Twin Echo Boy Scout camp), Stoops Ferry, and Wildewood; the Pine Creek limestone near Blackburn (one-half mile north of), Witmer (Refractory St.), and Woods Run; the Ames limestone near Glenwood, Pitcairn, and Pittsburgh (Brilliant Cut-off and Spring Garden); and the Birmingham Shale at Tenth Street tubes, Pittsburgh.

Hypotypes: Carnegie Museum, nos. 22,285-22,289.

Genus MOOREOCERAS Miller, Dunbar, and Condra, 1933

Mooreoceras normale Miller, Dunbar, and Condra

(Plate I, figures 6, 7)

(?) 1892. *Orthoceras colletti* Miller, Indiana Dept. Geol. and Nat. Resources Ann. Rept. 18, *Advance sheets*, pp. 67-68, pl. 10, fig. 1.
(?) 1894. *Orthoceras colletti* Miller, Indiana Dept. Geol. and Nat. Resources Ann. Rept. 18, pp. 321-322, pl. 10, fig. 1.
1931. *Orthoceras colletti* Morse, Kentucky Geol. Survey, ser. 6, vol. 36, pp. 300, 325-326, pl. 54, figs. 1, 2.
1933. *Mooreoceras normale* Miller, Dunbar, and Condra, Nebraska Geol. Survey Bull. 9, ser. 2, pp. 87-89, pl. 2, figs. 5-7.
1934. *Mooreoceras normale* Miller and Owen, Univ. Iowa Studies Nat. Hist., vol. 16, pp. 203-205, pl. 11, figs. 1-8.
(?) 1938. *Mooreoceras normale?* Miller and Moore, Jour. Pal., vol. 12, pp. 343-344.
1939. *Mooreoceras normale* Flower, Palaeontographica Americana, vol. 2, no. 10, pp. 146, 152.

This species is fairly abundant in the Conemaugh of Pennsylvania, and the collections we are studying contain about fifteen representatives of it. However, all of them are very incomplete, and our study has not enabled us to add to the existing morphological knowledge. It should, however, be stated that our specimens seem to be typical in all available particulars, though none of them is very large.

Occurrence: Representatives of this species are widely distributed in the Pennsylvanian system of the United States. Stratigraphically they are known to range from the Cherokee (and probably the Morrow) to the Wabaunsee. They have been found as far east as Pennsylvania, as far south as Texas, as far west as Colorado, and as far north as Michigan. In the Conemaugh of southwestern Pennsylvania they occur in the Brush Creek limestone near Creighton and Glassmere and in the Ames limestone near Ardara and Pittsburgh (Brilliant Cut-off).

Hypotypes: Carnegie Museum, no. 22,297.

Genus POTERIOCERAS M'Coy, 1844

Genotype: *Orthocera fusiformis* Sowerby

Conch breviconic, cyrtoceraconic, subcircular to broadly subelliptical in cross section, and characteristically large. Aperture only slightly contracted; its margins are directly transverse or slope orad from the dorsum, and only a shallow hyponomic sinus is present. Early sutures are trans-

verse but later ones slope orad from the venter. Siphuncle small, located between the venter and the center of the conch, cyrtochoanitic in structure, and composed of elliptical to subspherical segments. Lower Mississippian to mid-Pennsylvanian.

There is considerable variation in the species that are at present referred to this genus. The Pennsylvanian forms are much more rapidly expanded orad than is the genotype, as are certain of the Mississippian species. In at least the mid-Pennsylvanian representatives the surface of the test bears conspicuous transverse markings which probably represent increments of growth. The two species known from the Cherokee, *P. bransoni* and *P. mehli*, have rounded transverse constrictions on the dorso-lateral zones of the living chamber, but apparently these are confined to the internal mold. Also, in both of these species at full maturity the adoral suture is unique in that it curves away from the preceding suture on the lateral zones though it is close to and parallel with that suture on the dorsal and ventral zones.

The genotype occurs in the Lower Carboniferous of Ireland and England. In America congeneric forms are widespread geographically, and stratigraphically they range from the Kinderhook to the Conemaugh and the Kansas City.

Poterioceras curtum (Meek and Worthen)

(Plate II, figures 1-3; Plate V, figure 1)

1860. *Cyrtoceras curtum* Meek and Worthen, Philadelphia Acad. Nat. Sci. Proc., p. 468.

1860. *Cyrtoceras? dilatatum* Meek and Worthen, Philadelphia Acad. Nat. Sci. Proc., p. 468.

1861. *Cyrtoceras* (*Aploceras*) *curtum* Meek and Worthen, Philadelphia Acad. Nat. Sci. Proc., p. 148.

1866. *Cyrtoceras* (*Aploceras*) *curtum* Meek and Worthen, Illinois Geol. Survey, vol. 2, pp. 388-389, pl. 30, figs. 1a-1c.

1866. *Cyrtoceras? dilatatum* Meek and Worthen, Illinois Geol. Survey, vol. 2, p. 389, pl. 29, fig. 2.

1910. "*Cyrtoceras*" *curtum* Raymond, Carnegie Museum Annals, vol. 7, p. 156, pl. 25, fig. 6, pl. 26, fig. 8.

1911. "*Cyrtoceras*" *curtum* Raymond, Pennsylvania Topog. and Geol. Survey Comm., Rept. 1908-1910, p. 86, 87, 96, pl. 4, figs. 3, 4.

(?) 1915. *Cyrtoceras?* sp. Girty, U. S. Geol. Survey Bull. 544, p. 247, pl. 32, figs. 4-5a.

(?) 1924. *Cyrtoceras* sp. Morgan, [Oklahoma] Bur. Geol. Bull. 2, pl. 51, figs. 5, 5a.

The holotype of this species, which came from Illinois, is crushed and distorted and represents only an adapical portion of the conch, but we have additional specimens from Oklahoma and Pennsylvania that supplement it fairly well. The best one of these (Pl. II, figs. 1, 2) is from the Lansing of Oklahoma. It represents the adoral part of the phragmacone and the adapical part of the living chamber of what appears to be a mature individual. It is about 75 mm. long and the portion of the conch it represents is straight. In cross section it is circular, and at its adapical end it is about 50 mm. in diameter. Its sides diverge adorally at an angle of some 40 degrees. Near the adoral end of this specimen the test is about 2½ mm. thick. Its surface is marked by very distinct transverse striae, which appear to be confined to a surface layer of the test. Near the adapical end of the specimen these striae are less than 1 mm. apart, whereas on the adoral portion the distance between successive striae measures as much as 2½ mm. As in the holotype, the striae are sinuous and are not directly transverse. However, both their obliquity and their sinuosity may be the result of distortion during preservation for neither is symmetrical with respect to the siphuncular side of the conch. The siphuncle is small and is located fairly close to the venter; at the adapical end of the specimen under consideration, the siphuncle is about 2 mm. in diameter at its passage through a septum and its center is about 10 mm. from the venter.

The Pennsylvania specimens, all of which came from the Conemaugh, are rather fragmentary, but they represent various portions of the conch. Several of them retain the test, and it bears the same type of surface markings as does the holotype and the above-described Oklahoma specimen. Some of these Pennsylvania specimens are almost free from distortion, for example that represented by figure 1 on Plate V, and they show that the conch is circular (or nearly so) in cross section. Others, for example that represented by figure 3 on Plate II, show that the adapical portion of the conch is curved, as is the holotype.

Remarks: Although the specimens that we are referring to this species came from several rather widely separated localities, they seem to resemble each other in all available particulars. Furthermore, insofar as can be ascertained, all of them probably came from beds of the same general age. Better preserved uncrushed specimens may of course reveal significant differences, but we are convinced that for the present at least it will be best to regard all of them as representing only one species. Furthermore, as was suggested by Meek and Worthen, the holotype of *Cyrtoceras?*

dilatatum is almost certainly conspecific, and it merely represents a different portion of the conch than does the holotype of the species under consideration.

The specimens from the Wewoka formation of Oklahoma which Girty illustrated and described as *Cyrtoceras??* sp. and that from the same general horizon and locality which Morgan illustrated as *Cyrtoceras* sp. resemble *Poterioceras curtum* and are almost certainly congeneric with it. From the published data in regard to them, we are unable to tell whether or not they are conspecific. The holotype and only known representative of *Cyrtoceras peculiare* Girty, which also came from the Wewoka formation of Oklahoma, may also be a crushed representative of *Poterioceras*, but we are very uncertain in regard to its affinities.

Occurrence: The holotype came from the Pennsylvanian near Grayville, Illinois, and a conspecific specimen (the holotype of *Cyrtoceras? dilatatum*) has been described from the same general horizon near Springfield, Illinois. We have a single individual from the Eudora shale (Lansing) about 4½ miles northeast (4 miles north and 2 miles east) of Copan, Oklahoma; one from the Ames limestone on Davis Avenue near Brighton Road, and others from the Brush Creek limestone near Blackburn, Creighton, Donohoe, Glassmere (Harvy Brick Company quarry), and Stoops Ferry, all in southwestern Pennsylvania.

Hypotypes: University of Kansas, 23,420 (Pl. II, figs. 1, 2); Carnegie Museum (10 specimens including Pl. II, fig. 3, no. 22,291); and State University of Iowa, 3,116 (Pl. V, fig. 1) and 3,117 (unfigured specimen).

Poterioceras subellipticum, sp. nov.

(Plate II, fig. 4; Plate IV, fig. 4)

Conch large, rapidly expanded orad, subelliptical in cross section as depressed dorso-ventrally, and cyrtoceraconic being concave dorsally and convex ventrally. Holotype is not complete adorally or adapically, but the preserved part of it is about 160 mm. long. Its maximum width is about 115 mm. Near its mid-length its width and height are about 85 mm. and 55 mm., respectively, and at its adapical end these two measurements are about 30 mm. and 18 mm. The lateral zones of the conch diverge orad at an angle of about 48 degrees. In cross section the specimen is not quite elliptical as the ventral side of the conch is slightly but distinctly more strongly convex than the dorsal. The curvature appears to be

restricted to the adapical third of the specimen, and even there it is slight (Pl. II, fig. 4).

On at least the adapical portion of the conch, the surface of the test bears fine transverse lines about a millimeter or so apart. These are not preserved on the ventral side of the specimen, but they curve slightly apicad as they cross the dorsal side. No trace of sutures or siphuncle is discernible on the holotype.

Remarks: This species is being based on a single specimen which is moderately well preserved in limestone. It differs from *P. curtum*, which occurs rather widespread in the Pennsylvanian, in that its conch is subelliptical in cross section rather than subcircular. The specimen is very symmetrical and therefore its shape is almost certainly not a result of distortion.

Occurrence: National Stone Company quarry, about two miles northeast of Louisville, Nebraska, probably from the Argentine member of the Wyandotte limestone.

Holotype: Nebraska Geological Survey, T101.

Genus EPHIPPIOCERAS Hyatt, 1884

Ephippioceras ferratum (Cox)

(Plate I, figures 14, 15)

Recently Miller, Dunbar, and Condra (1933, pp. 114-118) published an exhaustive study of this species, including its complete synonymy. We have only three small very incomplete specimens, and they seem to be quite typical in all respects. One of them is crushed, but the other two are essentially free from distortion and are rather well preserved.

Occurrence: This species is widely distributed in the Pennsylvanian of North America. It is known to range from Pennsylvania on the east to Nebraska on the west. Stratigraphically it ranges from the base of the Cherokee to the top of the Lansing. The collections that we are studying from the Conemaugh of Pennsylvania contain two specimens from the Brush Creek limestone at Creighton and one from the Woods Run limestone in Jacks Run, Allegheny County.

Hypotypes: Carnegie Museum (2 specimens), and State University of Iowa, 3,128 (Pl. I, figs. 14, 15).

Genus MEGAGLOSSOCERAS Miller, Dunbar, and Condra, 1933

Megaglossoceras sp.

(Plate I, figure 16)

The genus *Megaglossoceras* is represented in the available collections from the Conemaugh of Pennsylvania by a single specimen. It is an internal mold of the adapical portion of the living chamber, and fortunately it elucidates the shape of the adoral septum. The conch is broadly rounded ventrally, flattened ventro-laterally, and narrowly rounded laterally. The umbilicus appears to be rather large for this genus. No trace of surface markings of the test is discernible. The single suture portrayed forms a moderately high and narrow rounded ventral saddle, and on either side of it a broad shallow broadly rounded asymmetrical lateral lobe, and a rather low narrowly rounded saddle centering on the umbilical shoulder.

Remarks: The suture of this form is similar to that of the genotype, *M. montgomeryense* (Worthen) of the McLeansboro of Illinois. However, since the Conemaugh specimen is small and very incomplete, satisfactory comparisons are not possible. Congeneric forms have been described from the Cherokee of Kansas and Missouri, the Lower Pennsylvanian of Colorado, and the Kansas City of Nebraska; also, the collections of the State University of Iowa contain undescribed representatives of the genus from the Boggy of Oklahoma and the Lansing of Missouri.

Occurrence: Brush Creek limestone at Witmer, Pennsylvania; Pine Creek limestone at Trafford City, Pennsylvania (affinities uncertain).

Figured specimen: State University of Iowa, 1,414.

Genus LIROCERAS Teichert, 1940

Liroceras sp.

(Plate I, figure 13)

The Conemaugh of southwestern Pennsylvania has yielded a single incomplete specimen that is referable to *Liroceras*. It represents the adapical quarter-volution of the living chamber and the adoral quarter-volution of the phragmacone. Its sutures are essentially straight and directly transverse, and its siphuncle is small and is subcentral in position. The shape of its conch is shown by Text figure 1 A.

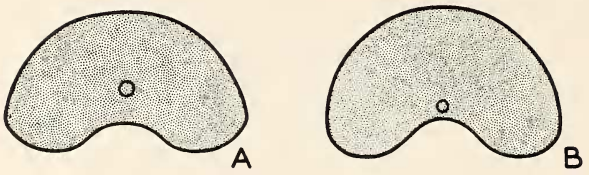

FIG. 1. Cross sections of two representatives of *Liroceras*, × 2. *A* is from the Conemaugh (Brush Creek limestone) near Glassmere, Pennsylvania; whereas *B* is from the Allegheny (Vanport limestone) near Wampum, Pennsylvania (C. M. 22,298). Same specimens shown in figures 11-13 on Plate I.

Remarks: In all respects this specimen seems to be a typical representative of *Liroceras*, but it is so small and incomplete that its specific affinities cannot be ascertained. The collections of the Carnegie Museum contain a congeneric form from the Allegheny (Vanport limestone) of the same general area. Like the Conemaugh specimen it is small and represents only about one-half of a volution of the conch. It is an internal mold of the adapical portion of the living chamber. It differs from the Conemaugh form in that its conch is less rapidly expanded orad, its whorls are narrower and higher, and its siphuncle is smaller and is closer to the dorsum (compare figures 11, 12 and 14 on Plate I, and Text figures 1 A and 1 B).

The genus *Liroceras* is widely distributed both stratigraphically and geographically, and it is well represented in the Mississippian, Pennsylvanian, and Lower and Middle Permian of both Eurasia and North America. In North America it is known to range from the Upper Mississippian (Chester) to the Middle Permian (Phosphoria).

Occurrence: Brush Creek limestone in the Harvy Brick Company quarry near Glassmere, Pennsylvania.

Figured specimen: State University of Iowa, 1,415.

Genus METACOCERAS Hyatt, 1883

Genotype: *Nautilus* (*Discus*) *sangamonensis* Meek and Worthen

Some thirty-five species are now referred to this genus. There is, to be sure, considerable variation amongst them, but for the most part they resemble the genotype rather closely. With a few exceptions the genus is fairly distinct and easily recognized, but species appear to be quite variable and more or less gradational.

Stratigraphically, *Metacoceras* has a long range; it appears in the Pottsville and continues until near the close of the Permian. The youngest American representatives of the genus known to us are in the collections of the U. S. Geological Survey; they came from the South Wells member of the middle Delaware Mountain formation (upper Middle Permian) in the Guadalupe Mountain region of west Texas. In northern Italy congeneric forms occur in the Bellerophon limestone, which is probably Upper Permian in age. Altogether, the genus is now known to be abundant and widespread in the Pennsylvanian of the United States, England, Belgium, and Soviet Russia; and it is represented also in the Permian of the United States, Italy, Russia, China, and Sumatra.

Metacoceras cornutum Girty

(Plate III, figures 1-5)

1910. *Temnocheilus winslowi* Raymond [not Meek and Worthen], Carnegie Museum Annals, vol. 7, p. 156.
1911. *Temnocheilus winslowi* Raymond [not Meek and Worthen], Pennsylvania Topog. and Geol. Survey Comm., Rept. 1908-1910, pp. 86, 88, 90, 96.
1911. *Metacoceras cornutum* Girty, New York Acad. Sci. Annals, vol. 21, pp. 145-146.
1915. *Metacoceras cornutum* Girty, U. S. Geol. Survey Bull. 544, pp. 240-242, pl. 29, figs. 4-5b.
1933. *Metacoceras cornutum* Miller, Dunbar, and Condra, Nebraska Geol. Survey Bull. 9, 2d ser., p. 168.

This form is by far the most abundant cephalopod species in the Conemaugh of Pennsylvania, and we have more than 65 representatives of it available for study. The largest of these (Pl. III, figs. 1-3) attains a maximum diameter of about 80 mm. and a maximum height and width of conch of about 32 mm. and 50 mm., respectively; the adoral third of the outer volution of this specimen represents the living chamber. During adolescence the ventral side of the conch is rather strongly convex, though it is distinctly flattened along the venter (Pl. III, fig. 4). At this stage of growth, ventro-lateral nodes are starting to develop, though they are barely discernible on the internal mold. During later growth stages, the ventral side of the conch becomes progressively less convex, and the ventro-lateral nodes become progressively more prominent. At full maturity these nodes are about as wide as long, and they are quite distinct from each other. The nodes are of course more prominent on the exterior of the test than on the internal mold.

Well-preserved testiferous specimens show that the growth-lines form a deep rounded ventral sinus. On the flattened lateral zones of the conch, the growth-lines are very slightly sigmoidal forming a salient next to the ventro-lateral shoulder and a sinus next to the dorso-lateral shoulder. On the broad flat umbilical walls, the growth-lines form slight salients. Their course across the shallow dorsal impressed zone can not be followed satisfactorily on the specimens under consideration.

The umbilical shoulders are very abrupt and the umbilical walls are very steep forming almost a right-angle with the flattened lateral zones of the conch. The test is much thicker than normal on the umbilical shoulders and it serves to accentuate their abruptness, making them almost angular.

The sutures are largely an expression of the shape of the conch in this species, and they form shallow broadly rounded ventral, lateral, and dorsal lobes. On the internal mold there is a slight but very distinct raised line along the venter. At maturity the siphuncle is located slightly ventrad of the center of the conch. It is small in size and orthochoanitic in structure. The septal necks are short and straight, and the connecting rings are only slightly expanded within the camerae.

Remarks: The paratype of this species does not appear from the published illustrations to be particularly similar to the holotype. The specimens we are studying resemble the paratype more closely than they do the holotype. Past experience has gone to show that a considerable amount of variation should be expected within species of the genus *Metacoceras*.

M. cornutum resembles the genotype, *M. sangamonense* of the McLeansboro of Illinois, rather closely but differs in that the lateral zones of its conch are slightly convex rather than concave and its umbilical walls are steeper. *M. perelegans*, which occurs in association with *M. cornutum* in both the Wewoka and the Conemaugh, differs particularly in that its umbilical shoulders are nodose. Also, its ventro-lateral nodes are more elongate longitudinally, and during adolescence the ornamentation of its test is much more prominent.

Occurrence: This species was originally described from the Wewoka formation of central Oklahoma. We are referring to it specimens from the following horizons and localities in the Conemaugh of southwestern Pennsylvania: the Brush Creek limestone near Creighton, Glassmere, Sewickley, Trafford, Valley Camp, Wildewood, Mars, Donohoe, Stoops Ferry, and Witmer; the Pine Creek limestone near Woods Run, Undercliff, Blackburn, Witmer, and Powers Run; the Woods Run limestone near

Jacks Run, Burke Glen, and Wilkinsburg; and the Ames limestone near Etna and Pittsburgh (Junction Hollow).

Hypotypes: State University of Iowa, 3,118 (Pl. III, figs. 1-5), 3,120-3,123 (several unfigured specimens), and 13,636, 13,637 (two unfigured specimens in the John Britts Owen Collection); and Carnegie Museum (numerous unfigured specimens).

Metacoceras perelegans Girty

(Plate I, figures 8-10; Plate III, figures 6-8)

1858. *Nautilus decoratus* Rogers [not Cox], The geology of Pennsylvania, a government survey, vol. 2, pt. 2, p. 833, fig. 692.
1910. *Temnocheilus crassus* Raymond [not Hyatt], Carnegie Museum Annals, vol. 7, p. 156.
1911. *Temnocheilus crassus* Raymond [not Hyatt], Pennsylvania Topog. and Geol. Survey Comm., Rept. 1908-1910, pp. 86, 88, 90, 96.
1911. *Metacoceras perelegans* Girty, New York Acad. Sci. Annals, vol. 21, pp. 147-148.
1915. *Metacoceras perelegans* Girty, U. S. Geol. Survey Bull. 544, pp. 244-245, pl. 30, figs. 5-6.
1933. *Metacoceras perelegans* Miller, Dunbar, and Condra, Nebraska Geol. Survey Bull. 9, 2d ser., p. 167.

Both of the figured syntypes of this species are small, but we are referring to it some large specimens (Pl. III, fig. 6) as well as some small ones. The last resemble the better of the figured syntypes rather closely. On the adapical part of these small specimens (Pl. I, fig. 10) the lateral zones of the conch bear prominent transverse ribs. As ontogenetic development proceeds the mid-portion of these ribs becomes less and less prominent, and the ribs therefore grade adorally into ventro-lateral and dorso-lateral nodes. Even during early adolescence the ventro-lateral ornamentation is more prominent than the dorso-lateral, and this disparity continues throughout ontogenetic development. The nodes are of course much more prominent on testiferous specimens than on internal molds.

All of the large specimens that we are referring to this species are crushed and distorted. However, the moderate-sized fragment represented by figures 8 and 9 on Plate I shows that at least during early maturity the whorls are almost rectangular in cross section as they are wider than high, essentially flat laterally and ventrally, only slightly impressed dorsally, and subangular ventro-laterally and dorso-laterally.

Where the conch of this specimen is about 19 mm. wide, it is about 12 mm. high and is impressed dorsally to a depth of only about 1 mm.

At full maturity the diameter of the umbilicus is equal to about two-fifths that of the specimens. The umbilical walls are broad and they are fairly steep.

The growth-lines show that the ventral side of the conch bears a broad deep rounded hyponomic sinus. On the umbilical shoulders and on the lateral zones of the conch the growth-lines are almost straight. The sutures form broad shallow rounded ventral, lateral, and dorsal lobes, as in other representatives of this genus. The siphuncle is small and is located slightly ventrad of the center of the conch.

Remarks: This species occurs in association with *M. cornutum* in both the Wewoka and the Conemaugh. It is readily distinguished from that species, however, by means of the umbilical nodes on its shoulders. Also, its adolescent ornamentation is much more prominent, and at maturity its ventro-lateral nodes are more elongate longitudinally.

Occurrence: The syntypes of this species came from the Wewoka formation of central Oklahoma. We are referring to it specimens from the following horizons and localities in the Conemaugh of southwestern Pennsylvania: the Brush Creek limestone near Ambridge, Creighton, Donohoe, Glassmere, Stoops Ferry, Trafford, Sewickley, and Valley Camp; the Pine Creek limestone near Trafford, Witmer, Powers Run, Blackburn, and Woods Run; and the Ames limestone at Brighton Heights. Raymond's lists indicate that this species occurs also in the Ames at the Brilliant Cut-off in Pittsburgh, but we have not been able to verify this occurrence.

Hypotypes: Carnegie Museum (Pl. I, figs. 8-10, nos. 22,295-22,296; and 10 unfigured specimens); and State University of Iowa 3,124 (Pl. III, figs. 7, 8), 3,125 (Pl. III, fig. 6), 3,126 and 3,127 (two unfigured specimens), and 13,638 (two unfigured specimens in John Britts Owen Collection).

Genus TAINOCERAS Hyatt, 1883

Tainoceras monilifer Miller, Dunbar, and Condra

(Plate IV, figures 1-3)

(?) 1871. *Nautilus Occidentalis* Meek [not Swallow], West Virginia Univ., Board of Regents 3d Ann. Rept., p. 71.

1872. *Nautilus occidentalis* Meek [not Swallow], Final Rept. U. S. Geol. Survey Nebraska. . . (U. S. 42d Cong., 1st sess., House Ex. Doc. 19), pp. 234-236, pl. 11, fig. 17.

(?) 1903. *Nautilus occidentalis* Meek [not Swallow], West Virginia Geol. Survey, vol. 2, p. 258 [but probably not p. 325].

1910. *Tainoceras occidentale* Raymond [not Swallow], Carnegie Museum Annals, vol. 7, pp. 147, 148, 149, 156, pl. 27, fig. 7.

1911. *Tainoceras occidentale* Raymond [not Swallow], Pennsylvania Topog. and Geol. Survey Comm., Rept. 1908-1910, pp. 90, 92, 93, 96, pl. 6, fig. 7.

(?) 1912. *Tainoceras occidentale* Mark [not Swallow], Ohio Geol. Survey Bull. 17, 4th ser., pp. 279, 281, 299.

1933. *Tainoceras monilifer* Miller, Dunbar, and Condra, Nebraska Geol. Survey Bull. 9, 2d ser., pp. 148-151, pl. 10, figs. 1-5.

This easily recognized species is represented by about twenty-five specimens in the collections from the Conemaugh of Pennsylvania that we are studying. All of these are crushed and distorted, and most of them are fragmentary. However, they supplement each other fairly well and portray the general characteristics of the species. They do not seem to differ materially from the holotype in any available particular, and our study of them does not enable us to add to the existing knowledge of the shell morphology.

Occurrence: The holotype of this species came from the Finis shale (basal Cisco) near Jacksboro, Texas. Conspecific specimens are known from the Cisco elsewhere in Texas; the Lawrence shale (Douglas), the Kereford limestone (basal Shawnee), and the Burlingame limestone (Wabaunsee) of Kansas; the Iatan limestone (Douglas) of Nebraska; and the Conemaugh of Pennsylvania and probably West Virginia and Ohio. We have specimens from the following horizons and localities in the Conemaugh of Pennsylvania: the Woods Run limestone at Abers Creek about eight miles east of Wilkinsburg; the Ames limestone in or near Allegheny (Brighton Heights and Riverview Park), Glenwood, Pitcairn, and Pittsburgh (Monument Hill and Brilliant Cut-off); and the Birmingham shale at Kennywood Park.

The genus *Tainoceras* is abundantly represented in the Pennsylvanian and the Lower Permian of the United States, and it occurs also in the Pennsylvanian of Russia and probably the Permian of Italy. However, most of the known species are readily distinguished from *T. monilifer.*

Hypotypes: All of the specimens figured and discussed in this report are in the Carnegie Museum (nos. 149, 10,434, 22,299).

Genus DOMATOCERAS Hyatt, 1891

Domatoceras spp.

(Plate V, figures 2-4)

We are referring more or less tentatively to *Domatoceras* a number of fragmentary specimens, all of which are crushed. These represent at least two species, but they are so incomplete that their specific affinities are very uncertain. Furthermore, even the generic affinities of some of the small specimens are highly questionable. The nodose specimen represented by figure 2 on Plate V differs markedly from the somewhat smaller specimens represented by figures 3 and 4 on the same plate, and its general physiognomy suggests that it is more or less intermediate between typical *Domatoceras* and typical *Stenopoceras*—no trace of sutures or siphuncle is discernible on it.

Occurrence: The specimens being referred to *Domatoceras* came from the following horizons and localities in the Conemaugh of Pennsylvania: the Brush Creek limestone near Creighton, Donohoe, Glassmere (Harvy Brick Company quarry), Witmer, and Valley Camp; the Pine Creek limestone near North Trafford, Powers Run, Verona, Witmer, and Woods Run; the Woods Run limestone near Burke Glen; and the Ames limestone near Glenwood and Pittsburgh (Brilliant Cut-off). In the Allegheny (Vanport) *Domatoceras* sp. is found at New Castle, Pennsylvania. Congeneric forms range in age from Lower Pennsylvanian to Upper Permian, and they are widespread in North America, Europe, and Asia.

Repository: State University of Iowa, 1,416-1,418 (Pl. V, figs. 2-4), 1,408 and 1,419 (unfigured specimens), and 13,640 (unfigured specimen in John Britts Owen Collection); and Carnegie Museum (numerous unfigured specimens).

Genus SOLENOCHILUS Meek and Worthen, 1870

Solenochilus brammeri Miller, Dunbar, and Condra?

(Plate VI, figs. 1, 2; Plate VII, figs. 3-6)

1910. *Solenocheilus collectus* Raymond [not Meek and Worthen], Carnegie Museum Annals, vol. 7, p. 156.

1911. *Solenocheilus collectus* Raymond [not Meek and Worthen], Pennsylvania Topog. and Geol. Survey Comm., Rept. 1908-1910, pp. 86, 88, 96.

The collections under consideration contain eleven representatives of the genus *Solenochilus*. All of them are incomplete and most of them are crushed. There seems to be no good reason to assume that more than one species is represented, and since the largest of the lot (Pl. VI, figs. 1, 2) appears to be quite similar to *S. brammeri*, it seems probable that all of them are related to that species.

The largest of the Conemaugh specimens, which is also the best, is about one-half of a volution in length. It represents the adoral two camerae of the phragmacone and much of the living chamber. The conch is subelliptical in cross section being broadly rounded ventrally, rounded laterally, and considerably wider than high. The umbilicus is small and is closed or nearly so. The umbilical zones of the conch are flared and are more or less carinate. The sutures are directly transverse and are almost straight, but they form very shallow ventral and lateral lobes and similar ventro-lateral saddles. The siphuncle is fairly small and is ventral in position, being in contact with the ventral wall of the conch or essentially so.

Remarks: The holotype of this species is much larger than the specimens we are studying—its diameter measures about 300 mm., whereas that of the largest of the Conemaugh specimens measures only about 125 mm. This disparity in size may or may not be significant insofar as taxonomy is concerned. Aside from size, the Conemaugh specimens do not appear to differ materially from the holotype in any available particular.

Occurrence: This species was originally described from the Argentine limestone member of the Wyandotte formation (Kansas City). We are referring to it with question specimens from the Brush Creek limestone at the following localities in southwestern Pennsylvania: near Creighton, Glassmere (Harvy Brick Company quarry), and just west of Murrysville; and from the Pine Creek limestone at Powers Run, Pennsylvania.

Raymond states that *Solenochilus* is represented also in the Brush Creek at Donohoe and Blackburn, Pennsylvania, and in the Pine Creek at Allegheny, Pennsylvania, but we have not been able to verify his identifications. Congeneric forms are widespread in both Europe and North America, and they range in age at least from Lower Mississippian to Lower Permian.

Repositories: State University of Iowa, 13,639 (John Britts Owen Collection), 1,420 (Pl. VII, fig. 5), and 1,421 (unfigured specimen); Carnegie Museum (Pl. VII, fig. 6, no. 22,290; and 6 unfigured specimens); and Ohio State University (Pl. VII, figs. 3, 4).

Genus PENNOCERAS, gen. nov.

Genotype: *Pennoceras seamani*, sp. nov.

Conch subglobular and whorls are broadly rounded ventrally and laterally. Living chamber at least a volution in length. Umbilicus small and closed or essentially so. Surface of test marked by prominent straight transverse lirae. Sutures consist of a rather broad bifid ventral lobe and on either side of it a rounded U-shaped first lateral saddle, a V-shaped but narrowly rounded first lateral lobe, a low broad rounded second lateral saddle, and a rounded lobe on the umbilical seam. The subdivisions of

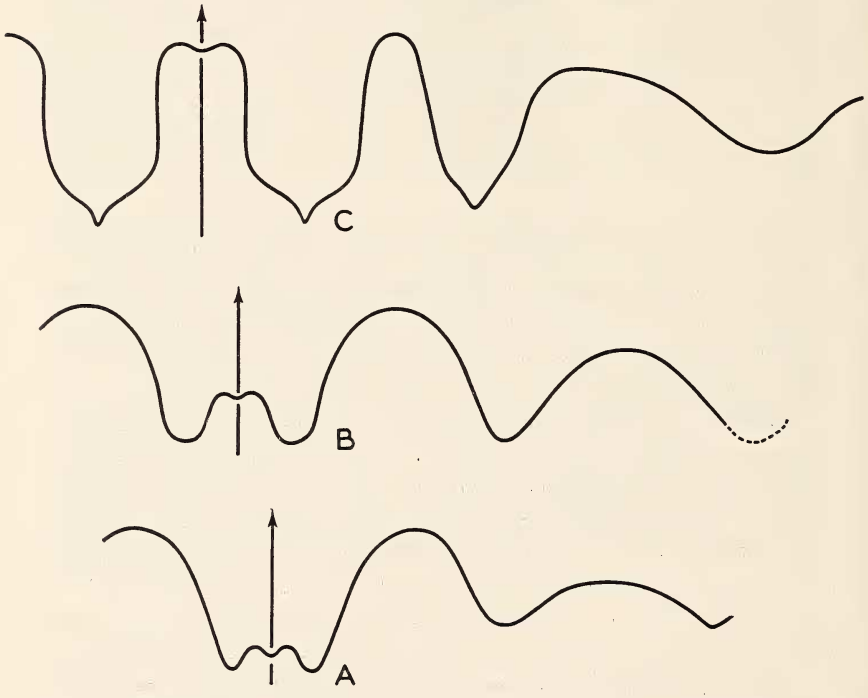

FIG. 2. Sutures of the genotypes of *Anthracoceras*, *Pennoceras*, and *Bisatoceras*.
A. *Anthracoceras discus* Frech of the basal Upper Carboniferous of Hohenlohegrube in southwestern Germany, considerably enlarged. Adapted from Frech.
B. *Pennoceras seamani*, sp. nov., of the Brush Creek limestone (Conemaugh) of southwestern Pennsylvania, × 11 (C. M. 22,292).
C. *Bisatoceras primum* Miller and Owen of the Seminole formation (lower Missouri) of northeastern Oklahoma, × 6.

the ventral lobe are rather short and are rounded. Conemaugh of Pennsylvania.

This genus is being established for three conspecific specimens in the collections that we are studying from the Conemaugh of southwestern Pennsylvania. It is possible that one of the type specimens of "*Goniatites*" *lunatus* Miller and Gurley may be congeneric. That species was based on three specimens from the Pennsylvanian of Elkhorn Creek, Kentucky. The largest of these and the second, which retains its sutures (Miller and Gurley, 1896, pl. 5, figs. 2, 4, and 5), are not closely related to the form under consideration, but the third (Miller and Gurley's pl. 5, fig. 3) has a subglobular conch and surface ornamentation similar to that of *P. seamani*. Until it is restudied its affinities will remain in question, but it is almost certainly not conspecific or even congeneric with the other two type specimens of "*G.*" *lunatus*.

Pennoceras resembles *Anthracoceras* and *Bisatoceras*. In *Anthracoceras* the sutures are in general similar, but the umbilicus is larger and the surface of the test does not bear prominent straight transverse lirae. *Bisatoceras* differs particularly in that the ventral lobe of its sutures is very broad and the subdivisions of that lobe are large, deep, and attenuate; also, the first lateral lobe is pointed and the first lateral saddle is relatively narrow.

Pennoceras seamani, sp. nov.

(Plate VIII, figures 7-13)

1910. *Goniatites lunatus* Raymond [not Miller and Gurley], Carnegie Museum Annals, vol. 7, p. 156.

1911. *Goniatites lunatus* Raymond [not Miller and Gurley], Pennsylvania Topog. and Geol. Survey Comm., Rept. 1908-1910, pp. 85, 86, 88, 96.

Conch moderately large and subglobular. It attains a maximum diameter of at least 37 mm. Whorls broadly rounded ventrally and laterally and impressed dorsally. Where they are about 8 mm. high, they are about 9 mm. wide and are impressed to a depth of about 3½ mm. Corresponding dimensions of larger whorls can not be ascertained from the available specimens as they are distorted. Living chamber at least one full volution in length. Umbilicus small, inconspicuous, and closed or essentially so. Umbilical shoulders broadly rounded.

Surface of test bears prominent lirae which are straight and are directly transverse. These are very closely spaced on the umbilical regions

but are relatively far apart on the ventral zones of the conch. Traces of the lirae are present on the internal mold.

Each external suture consists of a rather broad bifid ventral lobe and on either side of it a rounded U-shaped first lateral saddle, a V-shaped but narrowly rounded first lateral lobe, a low broad rounded second lateral saddle, and a rounded lobe on the umbilical seam. The subdivisions of the ventral lobe are only about two-fifths as deep as the entire lobe. They are of about the same size as the secondary saddle that separates them and are rounded. Text figure 2 B illustrates the shape of the sutures of the specimen represented by figures 7-9 on Plate VIII at a diameter of about 8 mm. It should perhaps also be mentioned that it appears to represent the adoral suture of that specimen.

Remarks: The above description is based on three specimens, only one of which shows the shape of the sutures. This specimen is also the only one that is free from distortion. The largest of the three (Pl. VIII, figs. 10, 11) has been considerably crushed and flattened laterally.

Occurrence: Brush Creek limestone near Creighton (McFetridge Brick Yard quarry) and Witmer, Pennsylvania. Also Raymond's lists seem to indicate that this species occurs in the Brush Creek near Donohoe and Bens Creek, Pennsylvania, and in the Pine Creek near Witmer, Pennsylvania—we have a well-preserved specimen from Witmer but it was collected long after the publication of Raymond's paper and it came from the Brush Creek.

Syntypes: Carnegie Museum (nos. 22,292-22,294).

Eoasianites sp.

(Plate VII, figs. 1, 2; Plate VIII, fig. 6)

We have six specimens from the Brush Creek limestone of southwestern Pennsylvania that are referable to *Eoasianites*. All are fragments of large septate individuals of 60 mm. or more diameter. Insofar as we can tell, they represent only one species. The whorls are low and broad and are broadly rounded ventrally but narrowly rounded laterally. The umbilicus is broad and deep. Sutures form a large prominently divided ventral lobe and on either side of it a high rounded first lateral saddle which is constricted near mid-height, a deep hastate acuminate first lateral lobe, a rounded asymmetrical second lateral saddle, and a small acuminate lobe on the umbilical shoulder. Although the umbilical walls are broad, the

sutures form no inflections on them. The internal sutures appear to be of the typical gastrioceran type.

Remarks: The above-described specimens are similar to *E. jonesi* (Miller and Owen) of the Seminole formation (basal Missouri) of Oklahoma, *E. excelsus* (Meek) of the basal Wabaunsee of Kansas, and possibly *E. globulosus* (Meek and Worthen) of the Pennsylvanian of Kansas and Oklahoma, as well as specimens from the Kansas City formation of Missouri recently described by Miller and Furnish (1940, p. 541, pl. 65, figs. 3-5) and compared with these species. The Conemaugh form differs particularly from equal-sized representatives of *E. jonesi* and *E. excelsus* in that the first lateral lobe of its sutures is relatively broad. No information is available in regard to the sutures of large specimens of *E. globulosus* and the Kansas City form if they exist.

Occurrence: Brush Creek limestone near Witmer, Glassmere, Sewickley, Donohoe, and Creighton, Pennsylvania.

Repository: State University of Iowa, 3,112 (Pl. VII, figs. 1, 2) and 3,113 (Pl. VIII, fig. 6); and Carnegie Museum (six unfigured specimens).

Genus SCHISTOCERAS Hyatt, 1884

Genotype: *Goniatites missouriensis* Miller and Faber

Conch subglobular to subdiscoidal and moderately large. Whorls somewhat depressed, rounded ventrally, slightly flattened laterally, and impressed dorsally. Living chamber appears to be about one volution in length. Diameter of umbilicus, which becomes relatively smaller during late ontogenetic development, varies from about one-fourth to about one-half diameter of specimen. During adolescence umbilical shoulders are nodose but nodes are lost before or during early maturity. Surface of test at maturity is marked by transverse growth-lines and typically by longitudinal lirae. Growth-lines form a deep rounded ventral sinus, prominent rounded ventro-lateral salients, and shallow lateral sinuses. Sutures consist of a large very prominently bifid ventral lobe, four pairs of pointed-spatulate external lateral lobes, a narrow pointed dorsal lobe, and two pairs of similar internal lateral lobes—altogether each mature suture consists of fourteen lobes. Siphuncle ventral and marginal in position throughout ontogenetic development. At maturity septal necks are entirely prosiphonate and are about one-fourth as long as camerae. Connecting rings cylindrical; they extend through the septal necks and therefore form a continuous tube.

During rather early ontogenetic development the sutures pass through a gastrioceran stage in which each consists of eight lobes. Then the umbilical lobes become lateral in position and a paralegoceran stage is achieved

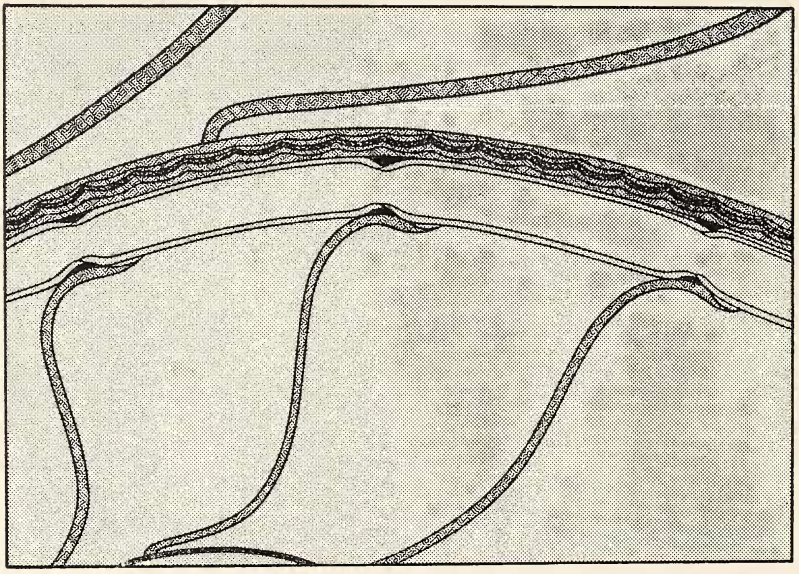

FIG. 3. Median longitudinal section of a portion of a mature whorl of *Schistoceras missouriense* (Miller and Faber) showing the structure of the siphuncle, × 20. Based on a specimen (State University of Iowa, 3,119) from the Finis shale (basal Cisco) about 3 miles east of Jacksboro, Texas.

as on each side of the conch a lobe is developed in the umbilical zone. This lobe becomes trifid and evolves into three lobes, the dorsal one of which is internal in position. In some cases the ventral one of these three becomes bifid, but this character is variable and apparently is to be accorded little taxonomic value. The sutures of *Schistoceras* are never comparable to those of *Metalegoceras;* in that genus the umbilical lobe of the gastrioceran stage becomes trifid and evolves into three lobes. In *Texoceras* and other adrianitids both external and internal lateral lobes are added consecutively in the umbilical zone rather than developed from a trifid umbilical lobe. The *Paralegoceras-Schistoceras* stock is one of the most important in the Pennsylvanian, but apparently it became extinct at or near the end of that period.

In spite of the fact that several paleontologists have emphasized that

all of the known representatives of *Schistoceras* are very similar, they have been divided into eleven species and three genera. In collaboration with W. M. Furnish we have assembled a large collection from various horizons and localities, and a direct comparison of specimens has convinced all three of us that only two forms are distinct enough to be recognized as species. One of these, which should be called *S. hildrethi* (Morton), is characterized by a large umbilicus, nodose umbilical shoulders during early maturity, and relatively prominent reticulate ornamentation. In the second species, *S. missouriense* (Miller and Faber), the umbilicus is relatively small during early maturity, the umbilical shoulders are smooth, and the ornamentation of the test is relatively fine and inconspicuous. All of these features are of course gradational, and forms are known that are intermediate between the two species. Furthermore, the two occur at several localities in direct association.

Smith proposed the name *S. hyatti* for the specimen on which the genus is based. However, as Miller and Furnish recently pointed out, that specific name should be suppressed as a synonym of *S. missouriense*, which then becomes the genotype. *Paraschistoceras* and *Metaschistoceras* are to be regarded as synonyms of *Schistoceras*.

The genus *Schistoceras* is now known from the lower Conemaugh of eastern Ohio and western Pennsylvania and the McLeansboro of central Illinois. In the Missouri-Kansas-Oklahoma Mid-Continent region it occurs at numerous horizons and localities ranging in age from the basal Missouri Seminole formation of Oklahoma to the Douglas group of the Virgil series in Kansas. In north-central Texas this genus is known from the upper Strawn, the Canyon, the lower Cisco, and possibly the Wichita; and in west Texas it ranges throughout most of the Gaptank. The specimen from central Asia which in 1931 Miller tentatively placed in this genus almost certainly does not belong here, but one species, *S. uralense* Ruzhencev, is known from the Upper Carboniferous of the southern Urals.

Schistoceras hildrethi (Morton)

(Plate VIII, figures 1-3)

1836. *Ammonites Hildrethi* Morton, Am. Jour. Sci. and Arts, vol. 29, pp. 40, 149, pl. 1, fig. 24 [probably not p. 137, pl. 28, figs. 48, 50, 53, 54].

1889. *Goniatites hildrethi* Miller, North American geology and palaeontology . . . , p. 439.

1898. *Agathiceras Hildrethi* Haug, Soc. géol. France Mém. Paléont., no. 18, pp. 33, 105-107, pl. 1, figs. 40a-c.

1903. *Schistoceras hildrethi* Smith, U. S. Geol. Survey Mon. 42, pp. 107-108, pl. 3, figs. 1, 2.

1930. *Schistoceras reticulatum* Miller, Jour. Pal., vol. 4, pp. 403-406, pl. 39, figs. 6-9.

1937. *Schistoceras unicum* Miller and Owen, Jour. Pal., vol. 11, pp. 420-422, pl. 52, figs. 16, 17.

1937. *Paraschistoceras hildrethi* Plummer and Scott, Texas Univ. Bull. 3701, pp. 17, 18, 22, 30, 33, 207, 240, 244, 247, 248, 250-251, 253, 255, 257, 379, 380, 387, 389, 390, pl. 14, figs. 1-14.

1937. *Paraschistoceras reticulatum* Plummer and Scott, Texas Univ. Bull. 3701, pp. 16, 17, 21, 22, 34, 246, 247, 253-255, 380, 382, 387, 388, 394, 399, pl. 14, figs. 15-18.

1937. *Paraschistoceras strawnense* Plummer and Scott, Texas Univ. Bull. 3701, pp. 16, 17, 247, 248-249, 387, pl. 14, figs. 22, 23.

1937. *Paraschistoceras costiferum* Plummer and Scott, Texas Univ. Bull. 3701, pp. 17, 252-253, 255, pl. 14, figs. 19-21.

1940. *Schistoceras hildrethi* Miller and Furnish, Jour. Pal., vol. 14, pp. 539-540 pl. 65, figs. 10, 11.

In 1836 Morton figured several specimens on which he based this species, but from his illustrations we are able to recognize the generic affinities of only one of them (Morton's pl. 1, fig. 24). This one may well be the same individual that Haug later found in a collection which Hildreth, who collected the types, had sent to France. Because of the measurements given by Morton, Haug concluded that he was probably not studying one of the original type specimens, but Morton's measurements elsewhere in the same paper are inconsistent. Furthermore, it is probably significant that Morton's illustrations are of almost precisely the same size as Haug's specimen, that in each case the specimens are stated to be silicified internal molds, and that insofar as it is possible to make comparisons the figures appear to be identical. Since Morton's illustrations are quite inadequate and his specimens are lost, whereas Haug's figures are quite satisfactory, the specimen studied by Haug is regarded as the type of the species.

The available collections from the Conemaugh of southwestern Pennsylvania contain four specimens that appear to be conspecific. Two of these, however, are crushed and therefore their specific affinities are somewhat questionable. The largest of the four, which is septate throughout, shows that the phragmacone attains a diameter of at least 45 mm. Where the specimen represented by figures 1 and 2 on Plate VIII is about 30 mm. in diameter, its conch is about 12 mm. high and about 18 mm. wide, and its umbilicus is some 12 mm. in diameter. The whorls are rather

low and broad. They are broadly rounded ventrally and laterally and are impressed dorsally. The umbilical shoulders are abrupt and are slightly nodose. It is estimated that there are about 25 nodes on each umbilical shoulder of the outer volution of the specimen represented by figures 1 and 2 on Plate VIII. The nodes appear to be somewhat elongate transversely.

The surface of the test is reticulate as it bears rather prominent longitudinal lirae and transverse growth-lines. The growth-lines are sinuous and each forms a rounded ventral sinus and on either side of it a similar ventro-lateral salient and a shallow lateral sinus. The shape of the external sutures is shown by Text figures 4 and 5 A. The ventral lobe is very

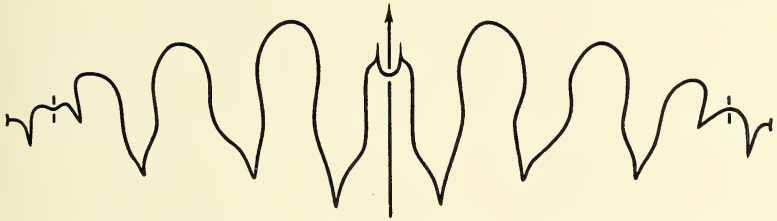

FIG. 4. Suture of *Schistoceras hildrethi* (Morton) at a diameter of about 30 mm., × 3. Based on the specimen represented by figures 1 and 2 on Plate VIII, which came from the Brush Creek limestone in the McFetridge quarry near Creighton, Pennsylvania.

prominently bifid and its subdivisions are as large as the first lateral lobe. The first and second lateral saddles are contracted near their mid-height. The first and second lateral lobes are acuminate and are asymmetrical. The third lateral saddle is very asymmetrical. The third lateral lobe is somewhat irregular in its development in that in some cases it is bifid whereas in others it is undivided. In the specimen represented by Text figure 5 A and by figure 3 on Plate VIII, the suture is preserved on only one side of the conch, and the third lateral lobe is bifid there. As shown by Text figure 4, in the specimen represented by figures 1 and 2 on Plate VIII the third lateral lobes are undivided, but there is a small lobe developed in the fourth lateral saddle on the right but not on the left side of the conch. The lobe on the umbilical wall is in all cases narrow and V-shaped.

Remarks: In this species the shape of the conch and the nature of the ornamentation and the sutures vary throughout ontogenetic development. During adolescence the umbilicus is relatively large, the umbilical

shoulders are conspicuously nodose, and the surface ornamentation of the test is relatively prominent. These ontogenetic variations, together with differences in preservation, are sufficient to explain most of the characters on which species that we regard as invalid have been based. Without an abundance of material it has been difficult to compare satisfactorily species established for testiferous specimens and those based on internal molds. Even topotypes are not infallible, for the large collections now available show that widely different types occur in direct association. There is, to be sure, more or less gradation between *S. hildrethi* and *S. missouriense*, but the extremes within the group are worthy of specific recognition.

Occurrence: The only one of the original type specimens of which we can recognize the generic affinities came from the Cambridge limestone near Cambridge, Ohio—this may be the specimen that was figured by Haug in 1898. We have a congeneric specimen from the same horizon and locality, but it is clearly not conspecific, being referable to *S. missouriense*. In the Conemaugh of southwestern Pennsylvania *S. hildrethi* occurs in the Brush Creek limestone near Creighton (McFetridge Brick Yard quarry) and Glassmere, in the Woods Run limestone at Abers Creek about 8 miles east of Wilkinsburg, and in the Ames limestone in Pittsburgh (Schenley Park)—the specific affinities of the specimens from the last two horizons and localities are somewhat questionable. Elsewhere, conspecific specimens have been found in the McLeansboro of Sangamon County, Illinois; the Muncie Creek member of the Iola formation (Kansas City group) at Kansas City, Missouri; the Iatan limestone of the Pedee group and the Stranger formation of the Douglas group in Douglas County, Kansas; the Seminole and Nellie Bly formations of Tulsa County, Oklahoma; the Nelagoney formation of Osage County, Oklahoma; the upper Strawn of Palo Pinto County, north-central Texas; the Graford formation of Palo Pinto and Wise counties, north-central Texas; the Graham formation (lower Cisco) of Brown, Jack, McCulloch, Stephens, and Young counties, north-central Texas; and the upper Gaptank formation of Brewster County, west Texas.

Hypotypes: State University of Iowa, 3,115 (Pl. VIII, figs. 1, 2) and 3,114 (Pl. VIII, fig. 3); and Carnegie Museum (two unfigured specimens of questionable specific affinities).

Schistoceras missouriense (Miller and Faber)

(Plate VIII, figures 4, 5)

1884. *Schistoceras* sp. Hyatt, Boston Soc. Nat. Hist. Proc., vol. 22, p. 336.
1892. *Goniatites missouriensis* Miller and Faber, Cincinnati Soc. Nat. Hist. Jour., vol. 14, pp. 164-165, pl. 6, fig. 1.
1896. *Goniatites fultonensis* Miller and Gurley, Illinois State Mus. Nat. Hist. Bull. 11, pp. 39-40, pl. 4, figs. 15-17.
1896. *Paralegoceras iowense* Smith [part], Am. Phil. Soc. Proc., vol. 35, pp. 263, 265.
1898. *Agathiceras Fultonensis* Haug, Soc. géol. France Mém. Paléont., no. 18, p. 33.
1903. *Schistoceras fultonense* Smith, U. S. Geol. Survey Mon. 42, pp. 106-107, pl. 16, figs. 15-17.
1903. *Schistoceras hyatti* Smith, U. S. Geol. Survey Mon. 42, pp. 108-111, pl. 20, figs. 1-8; pl. 21, figs. 10a-13.
1903. *Schistoceras missouriense* Smith, U. S. Geol. Survey Mon. 42, p. 111, pl. 8, fig. 1.
1919. *Schistoceras smithi* Böse, Texas Univ. Bull. 1762, pp. 93-95, pl. 3, figs. 9-16.
1919. *Schistoceras diversecostatum* Böse, Texas Univ. Bull. 1762, pp. 96-99, pl. 4, figs. 1-36.
1921. *Schistoceras hyatti* Plummer and Moore, Texas Univ. Bull. 2132, pp. 145, 146, 149, pl. 22, fig. 10.
1924. *Schistoceras fultonense* Morgan, [Oklahoma] Bur. Geol. Bull. 2, p. 124, pl. 53, figs. 8, 8a.
1929. *Schistoceras diversecostatum* Smith, Am. Jour. Sci. 5th ser., vol. 17, pp. 76-77, figs. B1-B13.
1930. *Schistoceras missouriense* Sayre, Kansas Univ. Sci. Bull., vol. 19, pt. 2, p. 158, pl. 21, figs. 4, 4a.
1930. *Schistoceras smithi* Miller, Jour. Pal., vol. 4, pp. 406-407, pl. 39, figs. 14-16.
1932. *Schistoceras hyatti* Sellards, Texas Univ. Bull. 3232, p. 114.
1937. *Schistoceras missouriense* Plummer and Scott, Texas Univ. Bull. 3701, pp. 17, 18, 30, 33, 201, 202-204, 206, 388, 399, pl. 19, figs. 1-15; pl. 20, fig. 11.
1937. *Schistoceras smithi* Plummer and Scott, Texas Univ. Bull. 3701, pp. 17, 22, 32, 34, 201, 205-206, 303, 387, 388, pl. 18, figs. 1-7; pl. 41, figs. 6-8.
1937. *Schistoceras diversecostatum* Plummer and Scott, Texas Univ. Bull. 3701, pp. 17, 22, 32, 34, 201, 206-207, 251, 255, 389, pl. 20, figs. 1-10.
1937. *Metaschistoceras heilprini* Plummer and Scott, Texas Univ. Bull. 3701, pp. 247, 256-257, 380, pl. 41, figs. 1-5.
1940. *Schistoceras missouriense* Miller and Furnish, Jour. Pal., vol. 14, pp. 540-541, pl. 65, figs. 6-9.

The holotype of this species, which came from the Kansas City group at Kansas City, Missouri, represents only one side of the conch. It is a rather well-preserved internal mold. Small fragments of the reticulate test adhere to the holotype, and conspecific testiferous specimens are known from the Graham formation (lower Cisco) of north-central Texas. Moderate-sized specimens have rather inconspicuous shell ornamentation, but during late maturity rather prominent longitudinal lirae are developed. On large specimens these longitudinal markings are distinctly more prominent than the transverse growth-lines.

The collections that we are studying from the Conemaugh of Pennsylvania contain three representatives of this species, and Plummer and Scott (1937, pl. 41, fig. 8) recently figured a specimen that is probably conspecific. Also, we have an exceptionally well-preserved internal mold from the Cambridge limestone of southeastern Ohio. All three of the available specimens from Pennsylvania are crushed and are none too well

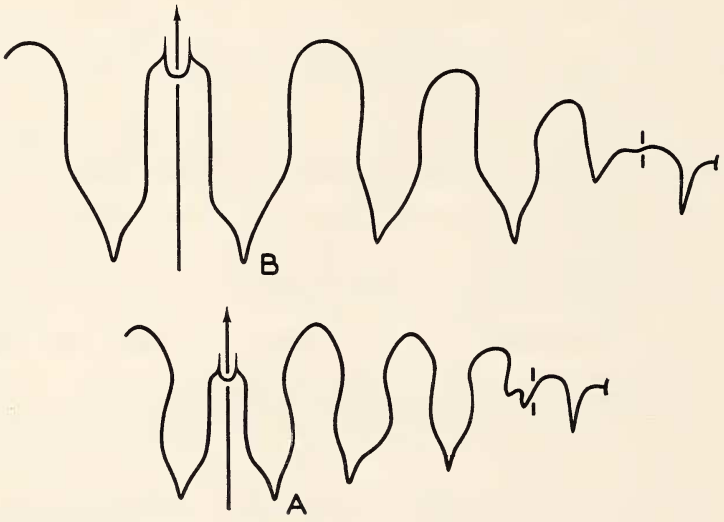

FIG. 5. Sutures of two species of *Schistoceras*.

A. *S. hildrethi* (Morton) at a diameter of about 25 mm., × 4; based on the specimen represented by figure 3 on Plate VIII, which came from the Brush Creek limestone near Glassmere, Pennsylvania.

B. *S. missouriense* (Miller and Faber) at a diameter of about 37 mm., × 3; based on the specimen represented by figures 4 and 5 on Plate VIII, which came from the Cambridge limestone about 4 miles northeast of New Concord, Ohio.

preserved. They are septate throughout and therefore represent only the phragmacone. All are of the same general size, and they show that the phragmacone attained a diameter of at least 77 mm. Where the diameter of one of these Pennsylvania specimens measures about 65 mm., its umbilicus is only about 13 mm. in diameter; corresponding measurements near the adoral end of the well-preserved Ohio specimen are about 45 mm. and 10 mm., respectively. The outer volution of the conch is flattened laterally, rounded ventrally, and impressed dorsally. The maximum width of the conch is attained at the umbilical shoulders. Near the adoral end of the Ohio specimen mentioned above, the conch is about 22 mm. high and about 24 mm. wide. As all of the Pennsylvania specimens are crushed, corresponding measurements can not be obtained.

Longitudinal lirae are prominent on even the adoral portion of the largest specimen being studied. They are distinctly more prominent there than are the sinuous transverse growth-lines. The shape of the sutures in this species is shown by text figure 5 B, which is based on the Ohio specimen. The sutures of the Pennsylvania specimens are quite similar in all available particulars.

Remarks: In general the characters of this species are slightly more advanced than are those of *S. hildrethi*, but all features are not consistent in this respect. In *S. hildrethi* the umbilicus is larger and the umbilical nodes and prominent reticulate ornamentation of the test are retained until a much larger size is attained by the conch. At least insofar as the size of the umbilicus is concerned, the specimen recently figured by Plummer and Scott appears to be more or less intermediate between typical *S. hildrethi* and *S. missouriense*.

Occurrence: The holotype of this species came from the Kansas City group at Kansas City, Missouri. The collections that we are studying from the Conemaugh of Pennsylvania contain conspecific specimens from the Brush Creek limestone in brick-yard quarries near Mars and Creighton—Plummer and Scott's specimen came from the same horizon at the latter locality. Also, we have a similar specimen from the Cambridge limestone in an abandoned quarry in the SW¼, NE¼, sec. 24, Adams Township, Guernsey County, southeastern Ohio. Other representatives of this species are known from the following horizons and localities: the Winterset, Westerville, and Iola (Muncie Creek member) formations at or near Kansas City, Missouri; the McLeansboro? of Fulton County, Illinois; the LaSalle limestone (McLeansboro) of LaSalle County, Illinois; the Belle City limestone of Seminole County, Oklahoma; the Graford

formation of Wise County, north-central Texas; the Graham formation of Brown, Jack, Stephens, and Young counties, north-central Texas; the Gaptank formation of Brewster and Pecos counties, west Texas; and possibly the Belle Plains formation (Wichita) of Callahan County, north-central Texas.

Hypotypes: State University of Iowa, 1,437 (Pl. VIII, figs. 4, 5); and Carnegie Museum (3 specimens).

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EXPLANATION OF PLATE I

All figures in natural size unless indicated otherwise.

FIGS. 1-5. *Pseudorthoceras knoxense* (McChesney)

1. A moderately large specimen, representing part of the phragmacone; from the Brush Creek limestone near Creighton, Pennsylvania, (C. M. 22,287).

2. A smaller specimen, the adoral end of which is crushed; from the same formation in Harvy quarry, Glassmere, Pennsylvania, (C. M. 22,285).

3. The extreme adapical portion of the conch; from the same formation near Donohoe, Pennsylvania, × 4 (C. M. 22,289).

4. A longitudinal section showing the siphuncle and the cameral deposits; from the same formation at the Twin Echo Boy Scout camp near Ligonier, Pennsylvania, × 4 (C. M. 22,286).

5. An internal mold showing the sutures; from the same horizon and locality as the preceding (C. M. 22,288).

FIGS. 6, 7. *Mooreoceras normale* Miller, Dunbar, and Condra.

Septal and dorsal views of a portion of a phragmacone; from the Brush Creek limestone near Creighton, Pennsylvania (C. M. 22,297).

FIGS. 8-10. *Metacoceras perelegans* Girty.

8, 9. Two views of an early mature portion of the conch; from the Brush Creek limestone near Creighton, Pennsylvania (C. M. 22, 295).

10. A distorted adolescent specimen; from the Pine Creek limestone near Witmer, Pennsylvania (C. M. 22,296).

FIGS. 11-13. *Liroceras* spp.

11, 12. Two views of an internal mold of the adapical part of the living chamber; from the Vanport limestone near Wampum, Pennsylvania (C. M. 22,298).

13. Ventral view of a specimen representing part of the phragmacone and the living chamber; from the Brush Creek limestone near Glassmere, Pennsylvania, × 1½.

FIGS. 14, 15. *Ephippioceras ferratum* (Cox).

Lateral and ventral views of a typical specimen from the Brush Creek limestone at Creighton, Pennsylvania.

FIG. 16. *Megaglossoceras* sp.

Ventral view of a fragment of an internal mold from the Brush Creek limestone at Witmer, Pennsylvania.


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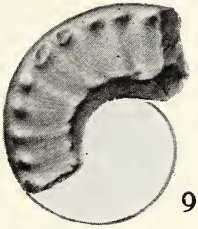
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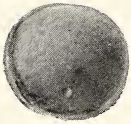
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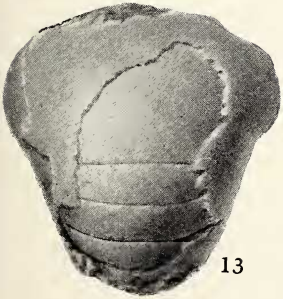
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EXPLANATION OF PLATE II

FIGS. 1-3. *Poterioceras curtum* (Meek and Worthen).

1, 2. Apical and ventro-lateral views of a testiferous specimen from the Eudora shale northeast of Copan, Oklahoma, × ¾.

3. A somewhat crushed testiferous specimen from the Brush Creek limestone, Glassmere, Pennsylvania, × ¾ (C. M. 22,291).

FIG. 4. *Poterioceras subellipticum*, sp. nov.

Lateral view of the holotype, which came from the Wyandotte limestone northeast of Louisville, Nebraska, × ¾. (See Plate IV for a dorsal view of this specimen.)

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EXPLANATION OF PLATE III

All figures in natural size.

FIGS. 1-5. *Metacoceras cornutum* Girty.

1, 2. Ventral and lateral views of a large, essentially complete, internal mold from the Brush Creek limestone near Glassmere, Pennsylvania.

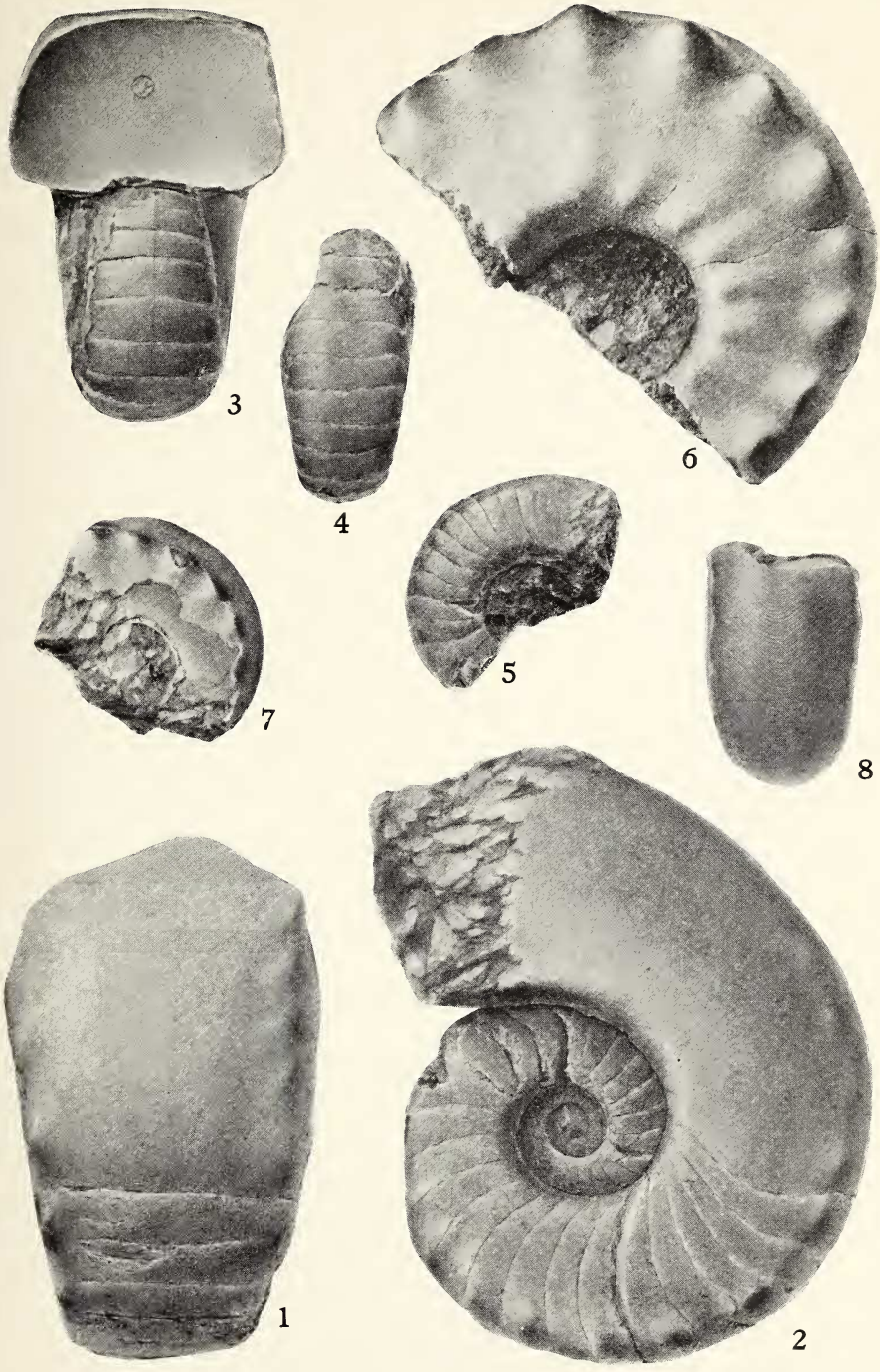
3. Ventral view of the phragmacone of the same specimen.

4, 5. Two views of an adolescent portion of a phragmacone from the same horizon and locality.

FIGS. 6-8. *Metacoceras perelegans* Girty.

6. Lateral view of a large mature testiferous specimen from the Brush Creek limestone near Creighton, Pennsylvania.

7, 8. Two views of an adolescent portion of the conch from the same horizon near Glassmere, Pennsylvania. The specific affinities of this specimen are somewhat questionable.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EXPLANATION OF PLATE IV

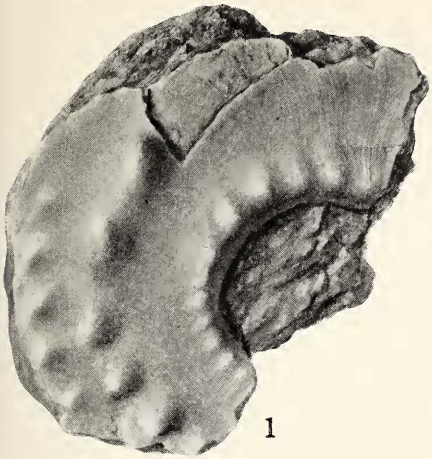
All figures in natural size unless indicated otherwise.

FIGS. 1-3. *Tainoceras monilifer* Miller, Dunbar, and Condra.

Three testiferous specimens, all of which are crushed and fragmentary; from the Ames limestone near Pitcairn, Pennsylvania. (Fig. 1, C. M., no. 10,434; fig. 2, C. M., no. 22,299). The specimen that was illustrated in 1910 and 1911 by Raymond (C. M. 149) is shown in figure 3.

FIG. 4. *Poterioceras subellipticum*, sp. nov.

Dorsal view of the holotype, which came from the Wyandotte limestone northeast of Louisville, Nebraska, × ¾. (See Plate II for a lateral view of this specimen.)



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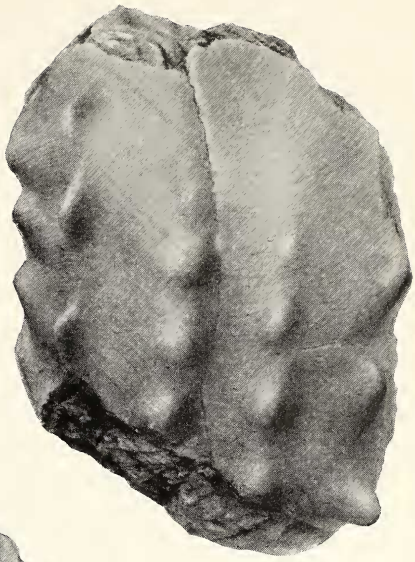

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